A Marine fires an M244 60 mm mortar system during a Tactical Air Control Party at a range outside Camp Taqaddum, Iraq. The M244 mortar system's elevation-traverse mechanics and bipod can be impacted by corrosion, and TARDEC engineers are working to find ways to prevent corrosion without the use of Cr^{6+}. (U.S. Marine Corps photo by CPL Jeremy Giacomino.)

application and operating environment standards.

- Update all relevant technical documents and specifications to authorize the use of suitable Cr^{6+} alternatives.
- Update the Program Environment, Safety and Occupational Health Evaluation for the system to document system-specific Cr^{6+} risks and efforts to qualify less-toxic alternatives and cost comparisons among alternatives, including disposal costs and system overhaul cycle times/costs due to any differences in corrosion protection.
- Require the program executive officer or equivalent, in coordination with the Military Department's Corrosion Control and Prevention Executive, to certify that there is no acceptable alternative to the use of Cr^{6+} on a new system.
- For such applications where acceptable alternatives to Cr^{6+} do not exist, Cr^{6+} may be used.

In addition, the memo describes that the Defense Acquisition Regulation Council has been tasked to prepare a clause to be added to all defense contracts — weapon system design, procurement and logistics support — that will prohibit the use of Cr^{6+}-containing materials unless specifically approved by the government. Additionally, the memo explains that the DOD "Advanced Surface Engineering Technologies for a Sustainable Defense" database will be expanded to incorporate knowledge management on RDT&E and experiences in using Cr^{6+} alternatives.

The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) Materials and Environmental Team (MET) has been working for many years to eliminate the use of Cr^{6+} from ground systems by inserting requirements into contracts prohibiting its use. In addition, the TARDEC MET participated in several pollution prevention projects to eliminate Cr^{6+}, including a project with Red River and Anniston Army Depots to evaluate alternative sealer/passivation chemistry to replace the Cr^{6+}-containing sealer/passivation currently used.

The TARDEC MET also is participating in projects to find a single coating for electrical connector shells and fasteners to replace the cadmium and Cr^{6+} chemistry currently used.

The TARDEC MET has identified and tested a feasible alternative to Cr^{6+} for fasteners and electrical connector shells using high-purity deposited aluminum. High-purity deposited aluminum is described in further detail in a sidebar accompanying this article. The MET is proposing a DOD-wide policy to replace cadmium plating with high-purity aluminum on fasteners and electrical connectors in materiel and maintenance. In addition, work has been done by various DOD organizations to find alternatives to Cr^{6+}, such as qualification of a Cr^{6+}-free aluminum conversion coating — qualified under MIL-DTL-81706 as Type II — and a zinc phosphate process for steel substrates as a solution to DOD-P-15328 wash primer. Information on alternatives to Cr^{6+} may be obtained by contacting the TARDEC MET. The points of contact for inquiries are I. Carl Handsy at (586) 574-7738 and Pam Khabra at (586) 574-5954.

The TARDEC MET has identified and tested a feasible alternative to Cr^{6+} for fasteners and electrical connector shells using high-purity deposited aluminum.

James Heading is a Professional Engineer and Certified Hazardous Material Manager who works as an Environmental Engineer with the TARDEC MET. He has a B.S. in environmental engineering from Michigan Technological University and is Level I certified in systems planning, research, development and engineering.

Single Replacement for Cadmium-Plated Fasteners and Electrical Connectors

I. Carl Handsy

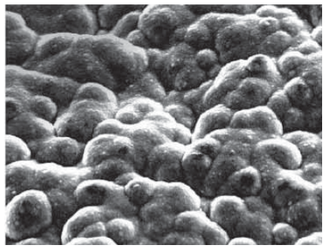

Figure 1. This Scanning Electron Microscope image depicts a plated surface shot at extremely high magnitude. A high-energy electron beam using a raster scan pattern produces the 3-D imagery.

TARDEC is proposing a policy to DOD components to replace cadmium plating for fasteners and electrical connectors in the procurement and maintenance of DOD materiel. This policy is driven by the need to reduce the quantity of toxic and hazardous chemicals and materials acquired, used and disposed of in DOD materiel. Cadmium and Cr^{6+} are known human carcinogens, and cadmium is required to be removed at the end of a product's life in conjunction with demilitarization. Except where specific requirements dictate a particular coating, all DOD fasteners and electrical connectors currently plated with cadmium should be procured with high-purity deposited aluminum coatings without hexavalent chromium treatment.

While several alternatives to cadmium plating exist, a single alternative has been selected after extensive testing to simplify the complexities within the supply and maintenance communities. There are thousands of different fasteners, and replacing them with multiple alternatives would be costly, would make parts inventories and national stock number management unwieldy and could introduce incompatible materials into maintenance operations. High-purity deposited aluminum has many benefits over cadmium, including:

- Superior corrosion performance at the same plating thickness as cadmium.
- Insusceptibility to hydrogen embrittlement, or grooving.
- The ability to be engineered for equivalent torque-tension.
- The ability to withstand high temperatures.
- High conductivity, which is necessary for electrical shell connectors.
- The ability to be produced without the use of Cr^{6+}, which has recently been restricted in an Under Secretary of Defense (Acquisition, Technology and Logistics) memorandum dated April 8, 2009, due to human health and environmental risks. The ability to withstand high temperature.

The primary challenge to implementing this technology is industrialization. To attain needed capacity, the manufacturing base will need to be expanded. This may require licensing a proprietary process or developing refined technologies from an expired patent. It also may impact the timeframe to phase in the new materials.

However, the benefits to implementing this technology far outweigh the challenges due to the toxicity that results from traditional cadmium plating. The technology has been accepted and is now standard practice for industry in Europe and gaining traction in the U.S. Based on this expanding use and the test results obtained during projects at TARDEC and other DOD organizations, using high-purity deposited aluminum is the logical solution for alleviating common long-term corrosion and environmental issues.

	AlumiPlate* Aluminum (Al)	Cadmium	Organic Coatings	Zinc Alloy Coatings	Ion Vapor Deposited Al
Nominal recommended thickness	0.3 mils	0.3 mils	1-2 mils	0.3 mils	0.3 mils
Salt spray (B-117) performance	1,000+ hrs	1,000 hrs	500 hrs	400-1,000 hrs	500 hrs
Non-embrittling	Yes	No	Yes	No	Yes
Fully dense and pore-free	Yes	Yes	Yes	Yes	No
Sacrificial protection	Yes	Yes	Partial	Yes	Yes
No galvanic reaction with Al parts	Yes	Yes	Partial	No	Yes
Complex geometrics and IDs	Yes	No	No	Yes	No
Tightly adhering	Yes	Yes	No	Yes	No
Environmentally friendly	Yes	No	Yes	No	Yes
High-temp. applicability	Up to 1,000 F	Up to 500 F	Up to 500 F	Up to 500 F	Up to 1,000 F
Drop-in gad replacement	Yes	—	No	No	No
No peening required	Yes	Yes	Yes	Yes	No
Ductile, formable and stampable	Yes	Partial	No	No	No
Low process temperature	Yes	Yes	Yes	Yes	No
Anodizeable	Yes	No	No	No	No

Figure 2. Aluminum Plating Performance Comparison.

I. Carl Handsy is a Senior Materials and Corrosion Engineer with TARDEC. He has a B.S. in chemistry from Lawrence Technological University and an M.S. in mechanical engineering from Wayne State University. He has taken post-graduate classes on organic coatings from the University of Missouri-Rolla. He is Level III certified in systems engineering.